AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph on Page 3, line 16 with the following amended paragraph.

FIGURE 3 illustrates a block diagram of the spa control system field ~~interconnection~~ interconnection panel.

Please add the following paragraph at Page 4, line 4.

FIGURE 14 illustrates diagrammatically a system constructed in accordance with the preferred embodiment.

Please replace the paragraph on Page 4, line 7 with the following amended paragraph.

Figures 1 and 2 illustrate a block diagram of the overall spa control system. The spa control system uses an intelligent microcomputer 10 to monitor and control the operation of the spa ~~(not shown)~~. The system uses solid state electronic components which eliminate many of the problems associated with traditional mechanical timer and relay control systems. The use of solid state electronic components increases the reliability of the system and reduces the maintenance necessary to maintain the spa in operable condition.

Please replace the paragraph on Page 4, line 12 with the following amended paragraph.

Referring to ~~Figure 1~~ Figures 1 and 14, the external system generally comprises a spa control panel 12 which is connected to a system ~~interconnection~~ interconnection panel 14. The system ~~interconnection~~ interconnection panel 14 is also connected to power input 16, to various sensors which detect parameters [[at]] such [[a]] as flow rate 18, temperature 20, 21 and pH 22 of the water [[22]], and also the mechanical and electrical components of the spa, such as the pump 24, heater 26, blower 28, and lights 30. The heater 26 may be interlocked to the pump 24 so that the pump 24 is continuously pumping water over the heating element ~~(not shown)~~ 29 of the heater 26 while the heater 26 is activated. This prevents a "hot spot" from developing in the spa system which could damage the components of the spa or give erroneous measurements.

Please replace the paragraph on Page 5, line 11 with the following amended paragraph.

NOVRAM 32 — This is a nonvolatile RAM device that is used to store the system calibration values as well as providing RAM expansion for the microcomputer 10. An EEROM image of the ~~current image~~ calibration values is stored when the powerfail interrupt is posted to the microcomputer 10 and restored when the microcomputer 10 powers up.

Please replace the paragraph on Page 5, line 21 with the following amended paragraph.

A/D 36 — This is an analog to digital converter that converts voltage inputs after signal conditioning at 37 to digital numeric representations. It provides three values: spa temperature 21, heater temperature ~~(both labeled 20)~~ 20 and pH value 22.

Please replace the paragraph on Page 7, line 13 with the following amended paragraph.

The display interface 38 is responsible for driving and updating the display device 40. When the microcomputer 10 sends information to this block 38 it is decoded and displayed on the screen 46.

Please replace the paragraph on Page 8, line 1 with the following amended paragraph.

The keyboard 48 (Figs. 1, 2 and [[6]]5) shown is a flat panel membrane style which is incorporated into the front panel. One type of keyboard 48 has ten push-buttons 50 and nine translucent cut-outs for backlighting of Light Emitting Diodes (LEDS) 52. The keyboard [[50]]48 is mounted on bezel 54 to provide a firm surface when depressing the buttons 50. The keyboard interface 56 provides circuitry which transmits information from the keyboard 48 to

the microcomputer 10. The keyboard interface 56 acts as an array of on/off switches that correspond to each keypad. The microcomputer 10 scans these switches as on/off, switch type input bits.

Please replace the paragraph on Page 8, line 9 with the following amended paragraph.

The Digital Outputs 58 drive the external spa devices, such as the ~~blower~~ pump 24, heater 26, [[pump]] blower 28 and other auxiliary devices. The low voltage signals are optically isolated at 60 and then drive a TRIAC device 62 which provides the high voltage and high current required by the external devices.

Please replace the paragraph on Page 8, line 13 with the following amended paragraph.

As previously set forth, the system ~~innerconnection~~ interconnection panel 14 connects the components of the spa control system. Referring to Figure 3, the power 16 to the system interconnection panel 14 is supplied through usual power supply. The Ground Fault Current Interrupter (GFCI) 64 provides protection to the system ~~innerconnection~~ interconnection panel 14 if an imbalance of current flow occurs through the Door Interlock 63 between the Input and the Output of the GFCI. The GFCI 64 prevents voltage and current from entering the system after the device 64 has been triggered. After the power has passed through the GFCI 64, the Power Supply 66 converts the 110 or 220 Volt AC into the low voltage and low power required by some components of the system. The power supply 66 also contains the backup battery or other device (not separately shown) used to provide power to the RTC 34 when the main power is turned off.

Please replace the paragraph on Page 9, line 19 with the following amended paragraph.

The Analog Input section 36 converts information from various sensors 20, 21, 22 into digital information so that the data can be read by the micrcomputer 10. The converter 36

translates the analog information into digital information through, for example, dual slope integration which permits fast and accurate conversion. The accuracy of the A-D section 36 typically is 8 bits or a resolution of 1 out of 256. The signals from external probes and sensors 20, 21, 22 are conditioned by amplifying, filtering, or conditioning the signals 37 so that the A-D converter 36 can make an accurate conversion. The Signal Conditioning section 37 also receives the [[small]] low signals from external probes 20, 21, 22 and amplifies it to a level where the A-D converter 36 can make an accurate conversion. This section 37 also provides transient and surge protection to reduce normal and common mode rejection noise.

Please replace the paragraph on Page 10, line 14 with the following amended paragraph.

The keyboard monitor routine 82 scans the keyboard and is triggered by the operation of any key. The key signal from the digital input is then decoded, and the main program 80 is triggered to initiate a series of programmed events. The program ignores multiple key depressions and erroneous entries and operates only upon the signal generated from a proper key entry. The display control program 84 converts data from the EPROM 44 to readable messages which can be shown on the display [[46]]40. The display control 84 handles the timing of the signals so that the display [[46]]40 performs in an efficient and proper manner. The alarm control 86 monitors the proper operation of the entire spa system. If the system malfunctions or otherwise operates incorrectly as measured by the input signals or data inferred from the input signals, the alarm will signal the malfunction to the panel 12. Examples of malfunctions in the system that might occur are the malfunction of the heater 26 and whether the pH 22 levels are within an acceptable range. In the event of a malfunction, a signal will be sent to the display controller 84 to display the alert signal and to alert the spa user of the malfunction.

Please replace the paragraph on Page 11, line 13 with the following amended paragraph.

The PID Control 92 constructions stands for proportional, integral and derivative control. This program 92 performs the closed loop control of temperature using the temperature input 20, 21 as its variable to be controlled and the heating elements [[26]]29 and the ouput to maintain control. The program 92 monitors the temperature 20, 21 of the water and determines when the heater 26 should be engaged. The program issues a command which activates the heater 26, and then monitors the temperature 20, 21 to determine when the heater 26 should be turned off. The program is unique in that it also monitors the rate of decrease and the rate of increase of the water temperature so that the final temperature of the water is not higher or lower than the selected temperature beyond the control supplied by [[*]]derivative control. The spa control system can achieve an accuracy of plus or minus one degree Fahrenheit with the heating and monitoring elements.

Please replace the paragraph on Page 12, line 8 with the following amended paragraph.

Figure [[5]]6 provides an overview of the program organization. Three events are handled by the system. Reset occurs when the system is powered up. It performs system initialization, enables the other events, and then calls the main program. The timer interrupt occurs periodically and inputs that require periodic polling are scanned. The power fail interrupt occurs when system power is failing. The primary purpose of this handler is to save the current system operating parameters within the time remaining before power fails completely. The function of certain subroutines is in one embodiment of the system are described in detail below.

Please replace the paragraph on Page 13, line 3 with the following amended paragraph.

*Initialize the RTC. [[It]] If the time was lost, it is reset to 12:00 midnight.

Please replace the paragraph on Page 14, line 19 with the following amended paragraph.

The main program 104 performs the bulk of the operations performed by the system controller. It synchronizes with the timer interrupt so that a reasonably constant timebase be is used. A state machine is maintained to determine how keyboard inputs are to be interpreted and what is to be displayed. The following tasks are performed by the main program:

Please replace the paragraph on Page 15, line 19 with the following amended paragraph.

Operator settings can be controlled by keys on the system ~~keypad~~ keyboard which are used to select modes that allow the operator to change settings that control system operations. These are grouped at the right side of the ~~keypad~~ keyboard. They are:

Please replace the paragraph on Page 16, line 6 with the following amended paragraph.

All of these functions adhere to a consistent operator interface scheme. When the function key is pressed, the LED 52 next to the key 50 is lit. The LED remains lit until all steps have been completed or another function has been selected. While setting a value, the value is displayed on the screen 46 and is flashed. The arrow keys are used to change the displayed value and the function key is pressed to proceed to the next step in the setting. While changes are being made, the display 40 stops flashing to avoid changes occurring while the display is in the off state. Once changes have stopped, the display resumes flashing. Changes are honored as they are made and the operator can change one step of a function without affecting the remaining steps. The current setting can be reviewed by pressing the appropriate function key repeatably. When a function that has been defined by the operator is currently being executed, the LED next to the corresponding button blinks.

Please replace the paragraph on Page 19, line 16 with the following amended paragraph.

CAL0 Calibrate analog channel 0 (spa temperature 21). This is a two point (32 and 104 degree) calibration for offset and gain correction.

Please replace the paragraph on Page 19, line 19 with the following amended paragraph.

CAL1 Calibrate analog channel 1 (heater temperature 20). This is identical to CAL0.

Please replace the paragraph on Page 26, line 1 with the following amended paragraph.

The Module ~~CTLACT Routine~~ CTLACT routine performs the following tasks:

Please replace the paragraph on Page 26, line 10 with the following amended paragraph.

The Module ~~CTLERR Routine~~ CTLERR - routine posts two errors and two warnings. The errors it checks for are frozen water and mismatch in temperature readings (flow error). The warnings it checks for are the water being too hot for safe usage and the pH reading out of safe limits.

Please replace the paragraph on Page 26, line 14 with the following amended paragraph.

The Module ~~CTLKEY Routine~~ CTLKEY - routine handles directly output keyboard inputs. In particular, it controls the light, jet and turbo. If the system is maintenance mode, no keys are processed. If the system is in an error state only the light key is processed. The controls are complemented each time the corresponding key is pressed.

Please replace the paragraph on Page 26, line 19 with the following amended paragraph.

~~The Module CTLLEDS Routine CTLLEDS if~~ If the module CTLLEDS-routine ~~CTLLEDS~~ operates [[when]] while the system is in maintenance mode, and the LED drive is disabled, the light, turbo and jet LEDS re driven solely on the output states. The heater LED is

driven steadily if the heater is on and flashed if the heater is off and has a request posted. The filter, set ready, scheduled heat and temperature LEDS are flashed if the corresponding function is posting a request and if the operator is not in a state used to set the function. If the operator is setting the function, the LED is already on and is not flashed.

Please replace the paragraph on Page 27, line 6 with the following amended paragraph.

The Module ~~Delay Routine~~ Delay routine provides a software waitloop style of delay routine used mainly during powerup.

Please replace the paragraph on Page 27, line 8 with the following amended paragraph.

The Module ~~DELTIME Routines~~ ADELTIME DELTIME routines are used to determine the interval between the current time and the specified time. DELTIME determines the time that has elapsed since the specified time while ADELTIME determines the time that remains until the specified time arrives.

Please replace the paragraph on Page 31, line 9 with the following amended paragraph.

The Module ~~Learn Routine~~ Learn routine is called as part of the control manager. If the heater is heating, the temperature value is monitored. If the temperature raises through two successive degree transitions, the time that elapsed between those two events is examined. If the time is less than one minute or two hours elapse before the event, a rate of change alarm is posted. Otherwise, the heating rate is stored for use in the spa ready function.

Please replace the paragraph on Page 32, line 6 with the following amended paragraph.

The Module ~~MYREGS Routine~~ MYREGS routine is called tc determine the address of the current context's register set. The address of RO is returned in the accumulator. This routine is used when the registers are going to be used as general memory locations for subroutine parameters.

Please replace the paragraph on Page 32, line 12 with the following amended paragraph.

The NOVREAD routine is called to restore the nonvolatile image of the NOVRAM. It is called at powerup. It begins the restore function and handles the proper delay interval to [[give]] the NOVRAM to complete the refresh.

Please replace the paragraph on Page 32, line 15 with the following amended paragraph.

The Module ~~POWRFAIL Routine~~ POWRFAIL routine is the powerfail interrupt handler and has previously been described.

Please replace the paragraph on Page 33, line 8 with the following amended paragraph.

The Module ~~ROMTEST Routine~~ ROMTEST routine is called at powerup to check the program EPROM or other ROM. It executes a simple data line test and reports failure if any errors are detected.

Please replace the paragraph on Page 34, line 4 with the following amended paragraph.

The SCHEAT module contains the routines that allow the user to configure the scheduled heating function. This allows the user to redefine the heating hysteresis when the spa is unattended. The minimal ~~hysteris~~ hysteresis value allowed is five degrees. The behavior of these routines has already been described.

Please replace the paragraph on Page 35, line 1 with the following amended paragraph.

The Module Start-~~Routine~~-Reset routine handles the powerup reset. Its function has previously been described.

Please replace the paragraph on Page 35, line 16 with the following amended paragraph.

The Module ~~TIMEBIN Routine~~ TIMEBIN routine is called to convert from BCD hours/minutes to a binary value in minutes.

Please replace the paragraph on Page 35, line 18 with the following amended paragraph.

The Module Timer-Routine ~~Timer~~ is the timer interrupt handler. Its behavior has previously been described.

Please replace the paragraph on Page 36, line 1 with the following amended paragraph.

The Module ~~UNMIL-Routine~~ UNMIL routine converts from military twenty-four hour format (used internally) to twelve hour am/pm format (preferred by most users).

Please add the following paragraphs on Page 36, line 14.

Figure 14 shows one possible configuration of the system of the present invention based on the above description. A spa, in accordance with normal convention, includes a container 11 for holding water 13 for bathers. The control panel 12 may be at spa side. As has been previously described, various output devices are installed in the system for the user of the system. As is well known in the art, conventional output devices include a heater 26, an air blower 28, a filter 27, lights 30, and a pump 24. Pump 24 may be separate pumps or one pump with a high and low speed. Heater 26 includes a heating element or heater core 29 for heating the water. Plumbing is provided with the system such as a plurality of pipes 35 for flowing water to and from the container 11. The low speed of pump 24 pumps water through pipes 35 causing the water to pass through filter 27 and heater 26 prior to flowing into container 11. The high speed of pump 24 flows water at high speeds through jet 37 mounted on container 11. The turbo or air blower 28 blows air into the water 13.

Various input devices are installed at selected locations within the system of the present invention and include sensors for detecting various parameters of the water and the system. Such sensors include the flow rate sensor 18, the temperature sensor 20 measuring the temperature of the water at the heating element 29, the temperature sensor 21 measuring the temperature of the

water in the container 11, and a pH probe 22 measuring the pH of the water in the container 11. As has been previously described, the input devices are connected to a system interconnection panel 14 which is connected to the control panel 12 and microprocessor 10 for receiving output signals from the various input devices. The system interconnection panel 14 is also connected to the various output devices for sending input signals to the various output devices.

Please replace the paragraph on Page 36, line 15 with the following amended paragraph.

Figure 5 shows one possible configuration of the keyboard 48 for the spa control panel 12. The overlay on the spa control panel 12 contains lights and a series of push button switches which can be depressed to switch on the appropriate functions. Preferably, an audible tone alerts the user that the computer 10 has received the signal sent by depressing the key. The jet button 49 operates the high speed pump 24 for the jet action in the spa. After the jet button 49 is depressed, the system will shut off the pump 24 if there is no flow in the system after five minutes of operation. The user is notified of the malfunction by an error message shown on the display. In a preferred embodiment, the low speed pump automatically is operated when the heater is activated. By pressing the jet button 24, the high speed overrides the low speed pump in pump 24. The heater 26 is still operable but the heating efficiency decreases because the water is moving faster over the heating element ~~(in 220v, in 110v high speed pump disables heater)~~. Interlocks link the pump 24 to the heater 26 so that the pump 24 runs fifteen seconds before the heater 26 is turned on and runs sixty seconds after the heater 26 is turned off. This ensures fluid flow during operation of the heater 26 so that hot spots in the system are not allowed to accumulate.

Please replace the paragraph on Page 37, line 10 with the following amended paragraph.

The air button 51 operates the blower motor (not shown) for the bubbling action in the spa (same interlock as jet/heater). The light button 53 operates any lights installed in the spa. The up arrow button 55 and down arrow button 63 are used in conjunction with the set clock 57, set temperature [[59]]65, set ready [[50]]61, scheduled heating 59, and filter [[61]]67 buttons. The purpose of the up arrow button 55 is to increment data that is presented on the display [[46]]40. The down arrow button 63 is used in conjunction with these same buttons to decrement data that is presented on the display. The set clock button 57 is used to set the current time of day and is activiated by pushing the set clock button 57. The desired time can then be set by activating the up arrow button 55 or the down arrow button 63. The set temperature button 65 can be used to control the temperature value for the thermostat 43 in the heater 26. To set the temperature, the set temperature button 65 is depressed and the current setting for the thermostat will be shown on the display. The up arrow button 55 or the down arrow button 63 can be used to increase or decrease the temperature setting as desired. When the desired value is shown on the display [[46]]40, the set temperature button 65 is depressed and the system will revert to the normal scroll in display. The ranges on the temperature setting may range from 40 to 104 degrees Fahrenheit.

Please replace the paragraph on Page 38, line 6 with the following amended paragraph.

Referring to ~~Figure~~ Figures 4 and 6, when the system is powered up, the system is reset at [[100]]104 by system initialization 102 which enables certain events and parameters and then calls the main program [[100]]110. Certain interrupts such as the timer interrupt 106 and the power fail interrupt 108 are enabled to detect future interrupts which can then be polled 100 or effect a system shutdown 112. The powerup reset 100 also generally clears all RAM 32, turns

off control outputs for devices 24, 26, 28, 30, initializes the real time clock 34 reading and the keyboard scanner 82, tests the NOVRAM [[32]] image for validity, and tests EPROM memory 44 (See Figure [[7]]2).

Please replace the paragraph on Page 39, line 13 with the following amended paragraph.

To operate the set ready, or spa ready mode, the set ready button [[50]]61 is depressed and the set ready light [[50]] and the hours light digits on display [[46]]40 are illuminated. The hours are set by using the up button 55 and down button 63 arrows. When the hours are correct, the set ready button [[50]]61 is depressed and the minutes digits will flash. The minutes data are set by using the up button 55 and the down button 63 arrows. When the minutes data is correct, the set ready button [[50]]61 is depressed and the current thermostat setting is displayed. The up button 55 or down button 63 arrow is pressed to select the proper temperature. The set ready button [[50]]61 is then depressed again and "on" or "off" will flash on the display screen [[46]]40. This indicates whether the feature is enabled or not. The set ready button 50 is again depressed and the data is entered. When it is time to begin the heating cycle, the system program LED on display 46 will flash to indicate that the feature is active.

Please replace the paragraph on Page 40, line 11 with the following amended paragraph.

The filtering button 67 allows the user to select the time for circulating the water in the spa for normal maintenance. To operate, the filter button 67 is depressed and the hours digits and the filter light will be eliminated. The up button 55 or the down button 63 is operated to select the hour, and the filter button 67 is depressed to set the new running time. The data is loaded into memory, the light next to filter button 67 will turn off and the display [[46]] 40 will return to the normal scroll in operation. When the filter functions are active, the LED will flash.

Please replace the paragraph on Page 41, line 5 with the following amended paragraph.

The system may be diagnosed by operating a switch 31 in the system ~~innerconnection~~ interconnection panel 14 to place the keyboard ~~54 in~~ 48 and display 40 in the diagnostics mode. By pressing the jet button 49, the total number of hours of operation on the pump 24 will be displayed. Pressing the air button 51 will show the total hours of operation on the blower motor. Pressing the set temp button 59 will display the total hours of operation on the heater 26 and will eliminate the set temp light. Pressing the set clock button 57 will display the total hours the system exceeded the desired temperature, designated as greater than 104 degrees Fahrenheit in the preferred embodiment. The light associated with the set clock button 57 will be eliminated after any other button is pressed. Pressing the up arrow button 55 or the down arrow button 63 will elimiante other modes and turn on all lights on the panel 54 and will turn on all segments of the display [[46]]40 along with the colon. The normal operation of the system is disabled when the maintenance switch is on. For example, the lights, turbo and jet outputs, and heater are shut down when the system is in maintenance mode.

Please replace the paragraph on Page 42, line 20 with the following amended paragraph.

In another embodiment of the invention, the system can monitor the temperature of the water at different locations in the system to determine whether there is blockage in the system. The spa system accomplishes this by monitoring the temperatures detected by sensors located at selected locations in the spa control system. In one embodiment of the invention, a first sensor ~~(now shown)~~ such as temperature sensor 20, which can be a solid state sensor, is located upstream of the heating element at a selected location and a second sensor ~~(not shown)~~ such as temperature sensor 21 is located downstream of the heating element. As water flows over the heating element of heater 26, the sensors detect the temperature of the water at the selected

locations. The microcomputer 10 processes the signals generated by the sensors and calculates the difference in temperature between the values detected by the sensors. The microprocessor selectively activates and deactivates the heating element of heater 26 to control the rate of heating. If the difference exceeds a selected amount, a warning on digital display 46, or other warning such as an audible sound, can be generated to warn the user of a malfunction in the spa. This function of the invention is shown in Figure 7.